

WHAT IS CLAIMED IS:

1. A fuel processor for steam reforming a sulfur-containing hydrocarbon fuel, the processor comprising:
  - 5 a desulphurization unit for reducing the sulfur content of a hydrocarbon fuel;
  - a pre-reformer for catalytically converting a reduced-sulfur hydrocarbon fuel to a mixture of C<sub>1</sub> and C<sub>2</sub> hydrocarbons; and
  - 10 a steam reformer for reforming the mixture of C<sub>1</sub> and C<sub>2</sub> hydrocarbons at a steam reforming temperature to a reformat comprising hydrogen and carbon dioxide, said catalyst bed comprising a carbon dioxide fixing material for fixing at least a portion of the carbon dioxide in the reformat.
- 15 2. The fuel processor of claim 1, wherein the hydrocarbon fuel is a diesel.
3. The fuel processor of claim 1, further comprising a vaporization unit upstream of the pre-reformer for vaporizing the hydrocarbon fuel.
- 20 4. The fuel processor of claim 1, further comprising a condenser downstream of the steam reformer for removing water from the reformat.
- 25 5. The fuel processor of claim 1, further comprising a unit downstream of the steam reformer selected from the group consisting of a methanation unit, selective oxidizer, and water gas shift reactor, for removing carbon monoxide, carbon dioxide or mixtures thereof, from the reformat.
- 30 6. The fuel processor of claim 1, wherein the catalyst bed comprises a steam reforming catalyst, said steam reforming catalyst comprises a precious metal catalyst.
- 35 7. The fuel processor of claim 1, wherein the catalyst bed comprises a water gas shift catalyst.
8. The fuel processor of claim 1, wherein the carbon dioxide fixing material is selected from an alkaline earth oxide, doped alkaline earth oxide and mixtures thereof.

9. The fuel processor of claim 1, wherein the pre-reformer comprises a catalyst suitable for converting the hydrocarbon fuel to a mixture of C<sub>1</sub> and C<sub>2</sub> hydrocarbons.
- 5
10. The fuel processor of claim 1, wherein the steam reformer comprises at least two catalyst beds and means for diverting feed streams between the at least two catalysts beds.
- 10
11. A method for steam reforming a sulfur-containing hydrocarbon fuel, the method comprising the steps of:
- reducing the sulfur content of a sulfur-containing hydrocarbon fuel to a reduced-sulfur hydrocarbon fuel;
- 15
- catalytically converting the reduced-sulfur hydrocarbon fuel to a mixture of C<sub>1</sub> and C<sub>2</sub> hydrocarbons;
- steam reforming the mixture of C<sub>1</sub> and C<sub>2</sub> hydrocarbons at a steam reforming temperature in a catalyst bed to produce a reformat comprising hydrogen and carbon dioxide; and
- 20
- fixing at least a portion of the carbon dioxide in the reformat with a carbon dioxide fixing material in the catalyst bed to produce a hydrogen-rich reformat.
12. The method of claim 11, wherein the sulfur-containing hydrocarbon fuel is a diesel.
- 25
13. The method of claim 11, further comprising the step of vaporizing a hydrocarbon fuel by mixing the hydrocarbon fuel with super heated steam.
- 30
14. The method of claim 11, further comprising the step of cooling the hydrogen-rich reformat.
15. The method of claim 11, further comprising the step of removing water from the hydrogen-rich reformat.
- 35
16. The method of claim 11, further comprising the step of removing carbon monoxide, carbon dioxide or mixtures thereof from the hydrogen-rich reformat.

17. The method of claim 16, wherein the amount of carbon monoxide and/or carbon dioxide in the hydrogen-rich reformat is reduced by  
5       subjecting the hydrogen-rich reformat to one or more of a water gas shift reaction, methanation, and selective oxidation.
18. The method of claim 11, wherein the carbon dioxide fixing material is an alkaline earth oxide, a doped alkaline earth oxide or a mixture thereof.  
10
19. The method of claim 11, further comprising the step of heating the carbon dioxide fixing material to a temperature above the steam reforming temperature to release fixed carbon dioxide.
- 15   20. The method of claim 19, wherein the carbon dioxide fixing material is heated to a temperature above 550° C.
21. The method of claim 11, further comprising the step of heating a first catalyst bed to a temperature above the steam reforming temperature to release fixed carbon dioxide while steam reforming the mixture of C<sub>1</sub> and C<sub>2</sub> hydrocarbons in a second catalyst bed.  
20
22. An apparatus for generating electricity, the apparatus comprising:  
25       a fuel processor comprising a desulphurization unit for reducing the sulfur content of a hydrocarbon fuel, a pre-reformer for catalytically converting a reduced-sulfur hydrocarbon fuel to a mixture of C<sub>1</sub> and C<sub>2</sub> hydrocarbons, and a steam reformer for reforming the mixture of C<sub>1</sub> and C<sub>2</sub> hydrocarbons at a steam reforming temperature in a catalyst bed to a reformat comprising hydrogen and carbon dioxide, said catalyst bed comprising a carbon dioxide fixing material for fixing at least a portion of the carbon dioxide in the reformat to produce a hydrogen-rich reformat; and  
30       a fuel cell configured to receive the hydrogen-rich reformat from the fuel processor and wherein the fuel cell consumes a portion of the hydrogen-rich reformat and produces electricity, an anode tail gas, and a cathode tail gas.  
35

23. The apparatus of claim 22, further comprising a combustor in fluid communication with the pre-reformer and/or catalyst bed for producing a heated exhaust gas.
- 5 24. A method for generating electricity, the method comprising the steps of:  
reducing the sulfur content of a hydrocarbon fuel;  
converting a reduced-sulfur hydrocarbon fuel to a mixture of C<sub>1</sub> and  
C<sub>2</sub> hydrocarbons;  
10 steam reforming the mixture of C<sub>1</sub> and C<sub>2</sub> hydrocarbons at a steam  
reforming temperature in a catalyst bed to produce a reformat  
comprising hydrogen and carbon dioxide; and  
fixing at least a portion of the carbon dioxide in the reformat with a  
carbon dioxide fixing material in the catalyst bed to produce a  
hydrogen-rich reformat; and  
15 feeding the hydrogen-rich reformat to an anode of a fuel cell,  
wherein the fuel cell consumes a portion of the hydrogen-rich  
reformat and produces electricity, an anode tail gas, and a  
cathode tail gas.
- 20 25. The method of claim 24, further comprising the step of feeding the  
anode tail gas and/or the cathode tail gas to an anode tail gas oxidizer  
to produce an exhaust gas.
- 25 26. The method of claim 24, further comprising the step of heating the  
carbon dioxide fixing material to a temperature above the steam  
reforming temperature to release fixed carbon dioxide.
27. The method of claim 25, further comprising the step of reducing the  
amount of carbon monoxide and/or carbon dioxide in the hydrogen-rich  
30 reformat by subjecting the hydrogen-rich reformat to one or more of  
a water gas shift reaction, methanation, and selective oxidation.